Recent Jet and Heavy Flavor Results at PHENIX

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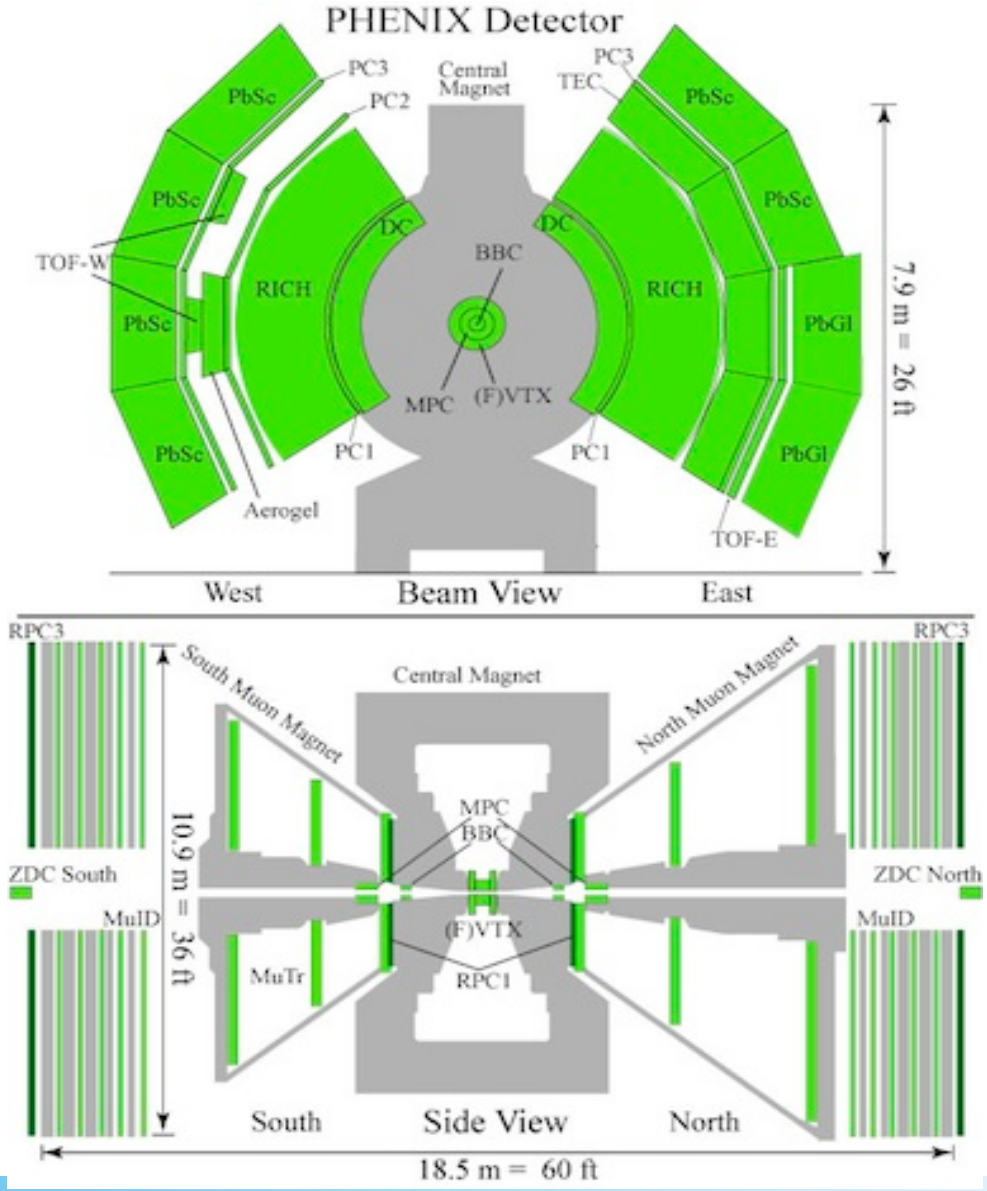
PHENIX

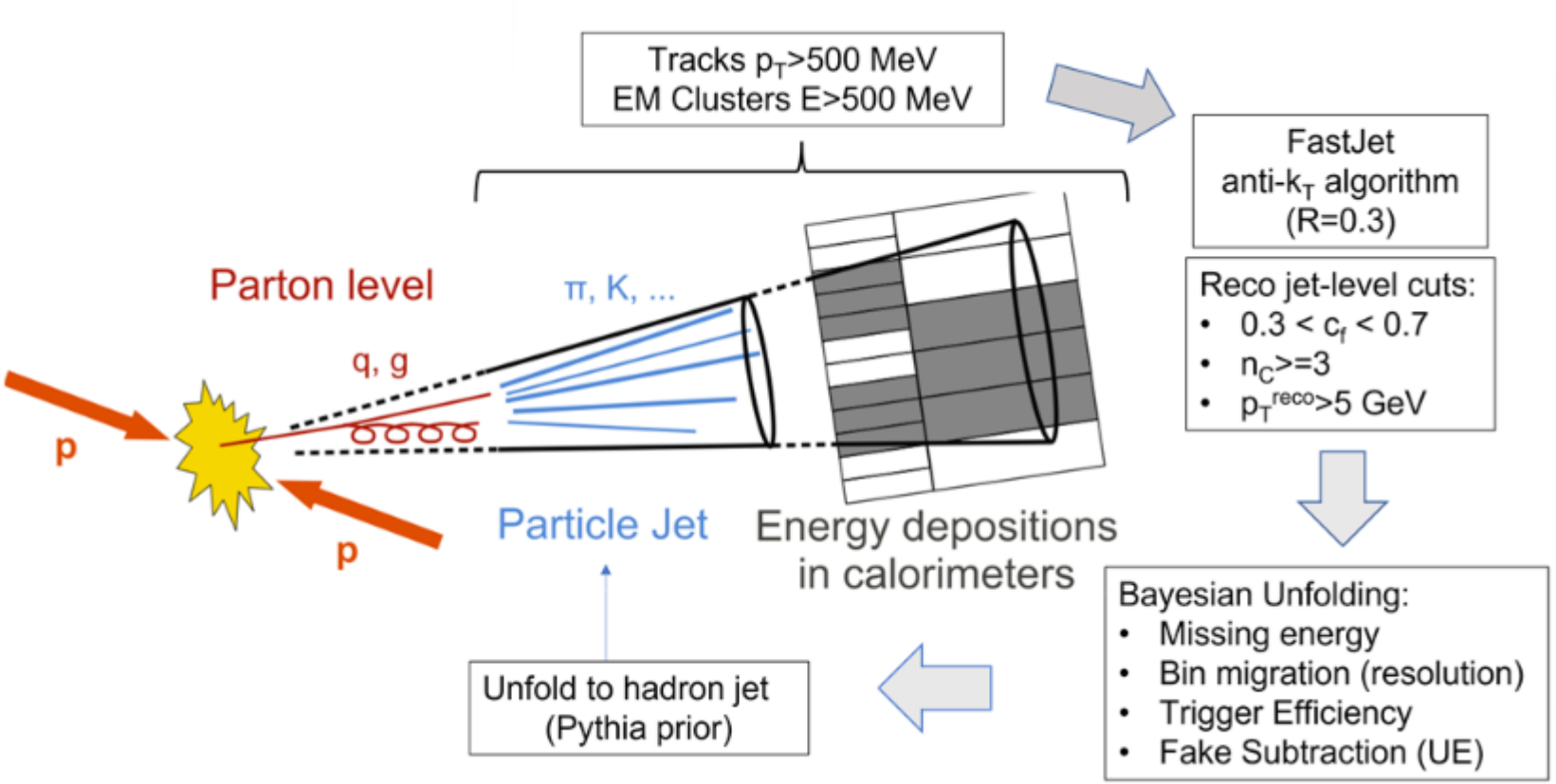
PHENIX Experiment

- Central Arms (|η| < 0.35)
  - Tracking: DC and PC
  - EM Calorimeter
- Forward Arms
  - Muon arms (1.2 < |η| < 2.4)
  - Zero Degree Calorimeter (ZDC)
- Completed data collection in 2016



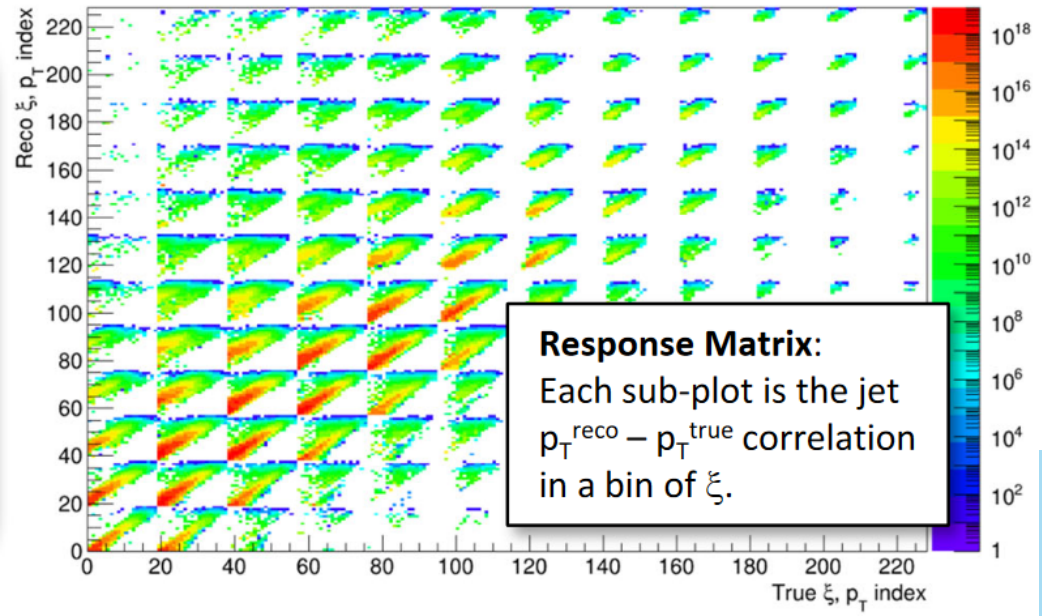
Jets Reconstruction

- Tracks and clusters are combined using anti-k_T algorithm to get R = 0.3 jets
- Unfolded to account for missing energy, trigger efficiency, etc.



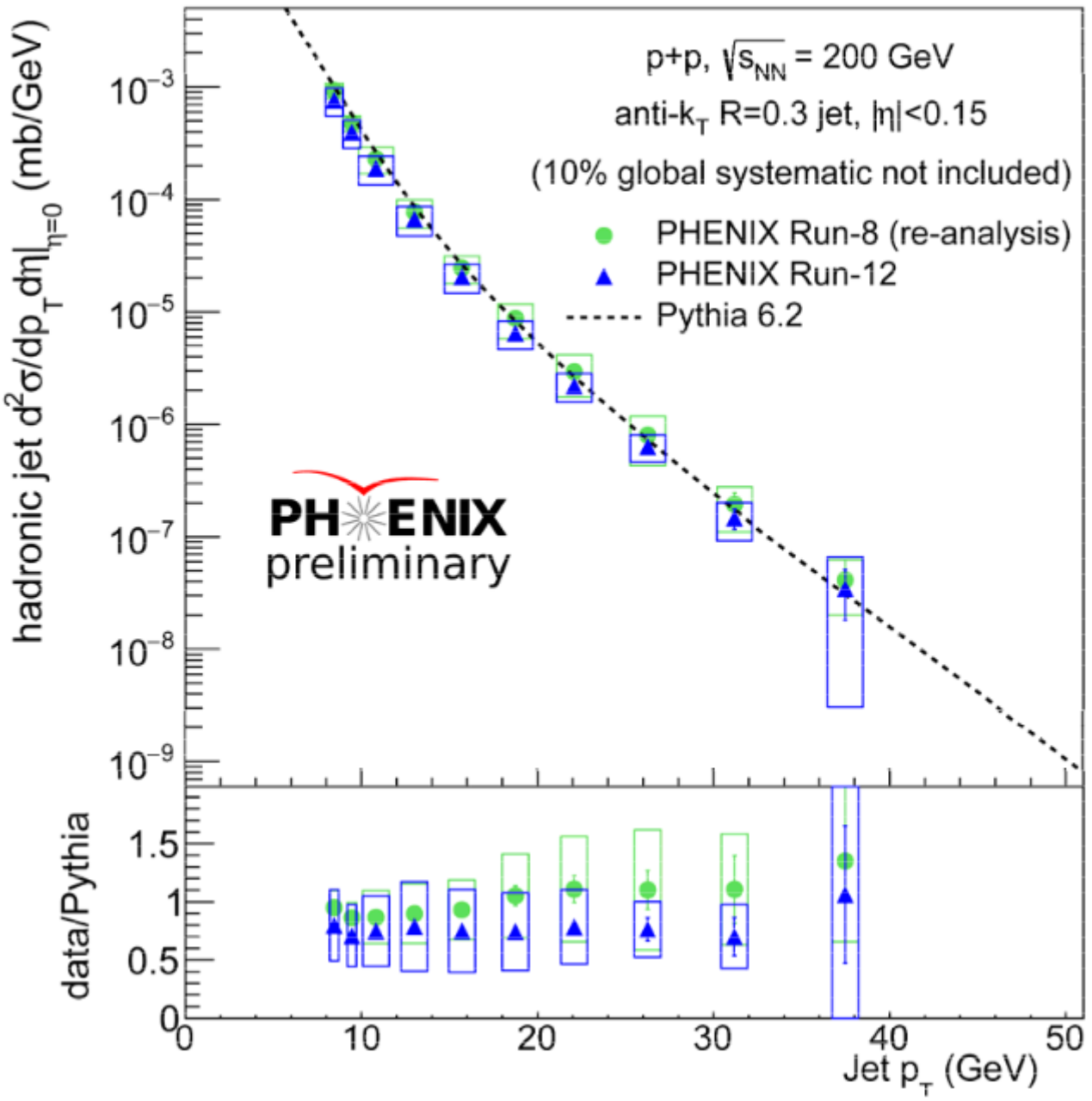
2-Dimensional Unfolding

- For jet substructure, the 2D unfolding is done in jet p_T and appropriate substructure quantity
  - e.g. groomed momentum fraction, z_g
- Pythia prior is iteratively tuned to match the mean number of charged particles in a jet as a function of jet p_T



Jet Cross Section

- Cross section for p+p √s = 200 GeV
- Run 8 re-analysis and Run 12 agree well and with Pythia



Jet Substructure

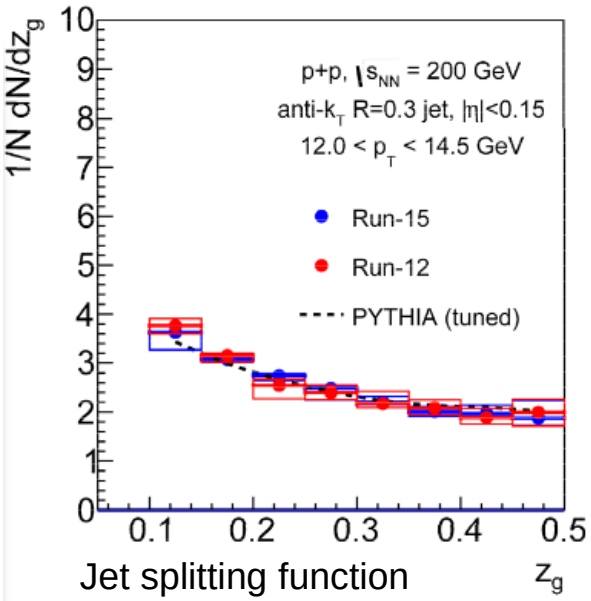
- The low jet p_T bin

$z_g = \min(p_{T1}, p_{T2})/(p_{T1}+p_{T2})$
(Soft Drop, $\beta=0$, $z_{cut} = 0.1$)

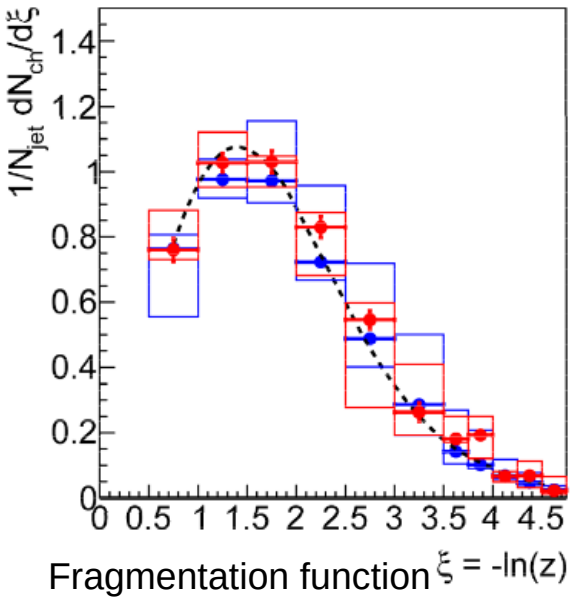
$\xi = -\ln(z)$, $z = \frac{\vec{p}\cdot\vec{p}_{JET}}{p\, p_{JET}}$
(Fragmentation Function)

j_T (Constituent mom. $\perp$ to jet axis)

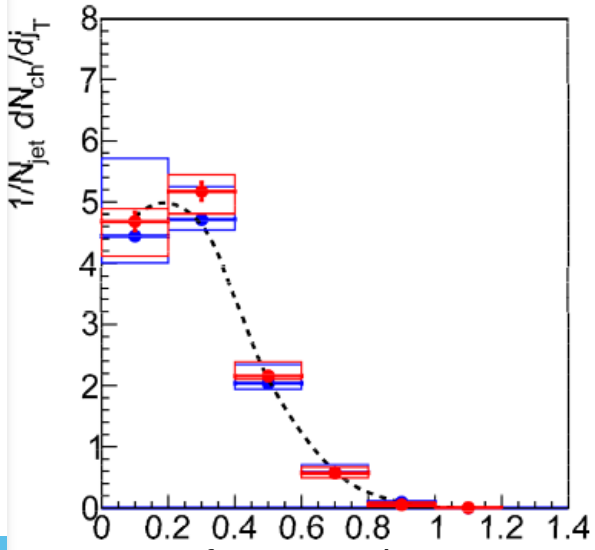
$\Delta R = \sqrt{(\phi - \phi_{jet})^2 + (\eta - \eta_{jet})^2}$
(Constituent distance from jet axis)



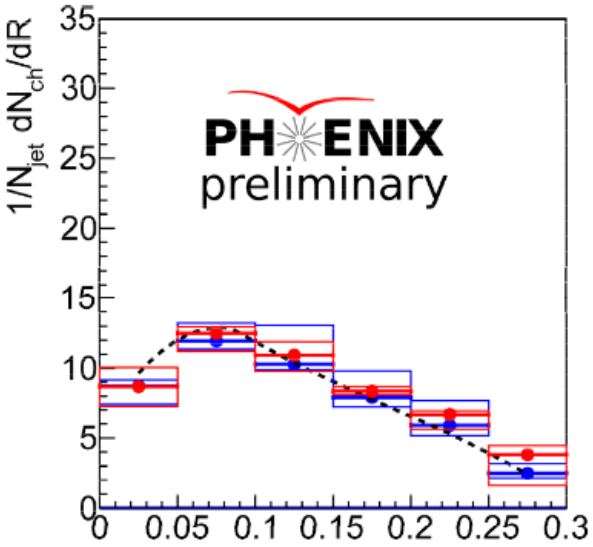
Jet splitting function



Fragmentation function



Transverse fragmentation



Radial profile

Jet Substructure II

- The high jet p_T bin

$z_g = \min(p_{T1}, p_{T2})/(p_{T1}+p_{T2})$

(Soft Drop, $\beta=0$, $z_{cut} = 0.1$)

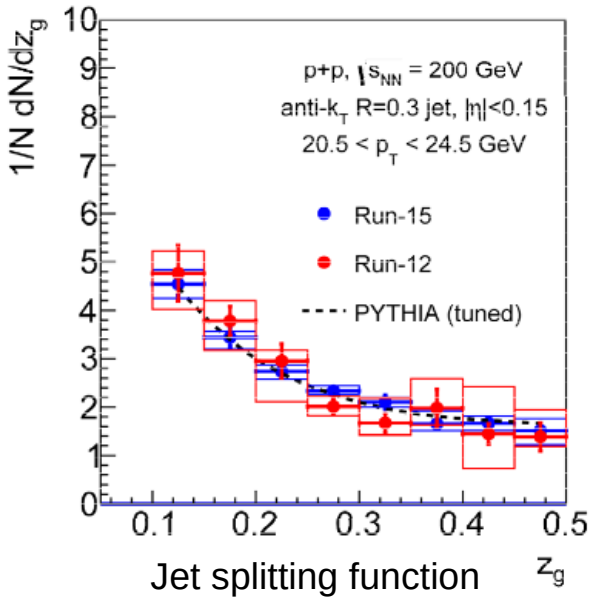
$\xi = -\ln(z)$, $z = \frac{\vec{p}\cdot\vec{p}_{JET}}{p\, p_{JET}}$

(Fragmentation Function)

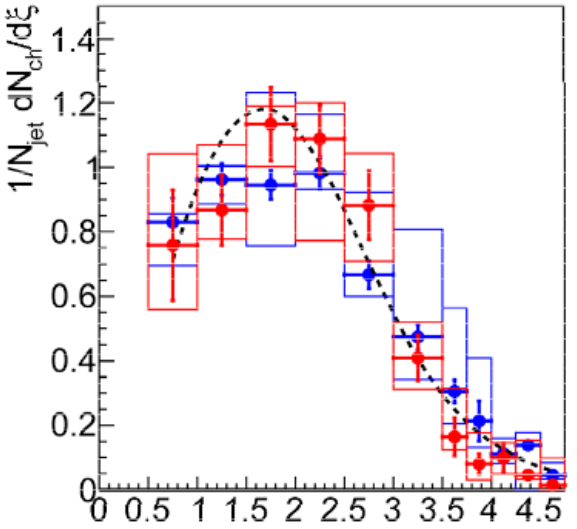
j_T (Constituent mom. $\perp$ to jet axis)

$\Delta R = \sqrt{(\phi - \phi_{jet})^2 + (\eta - \eta_{jet})^2}$

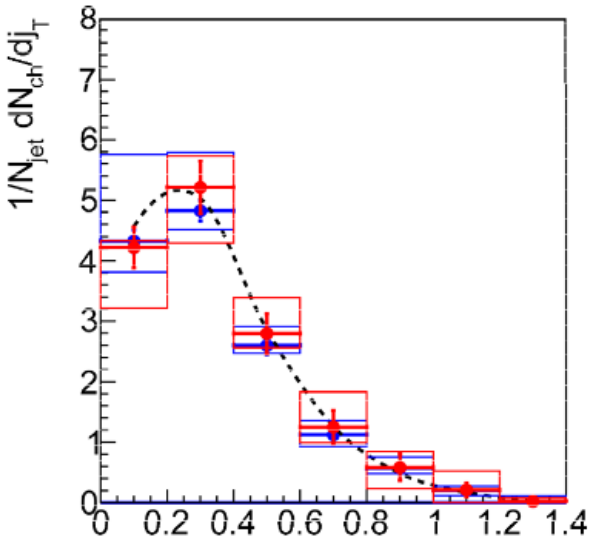
(Constituent distance from jet axis)



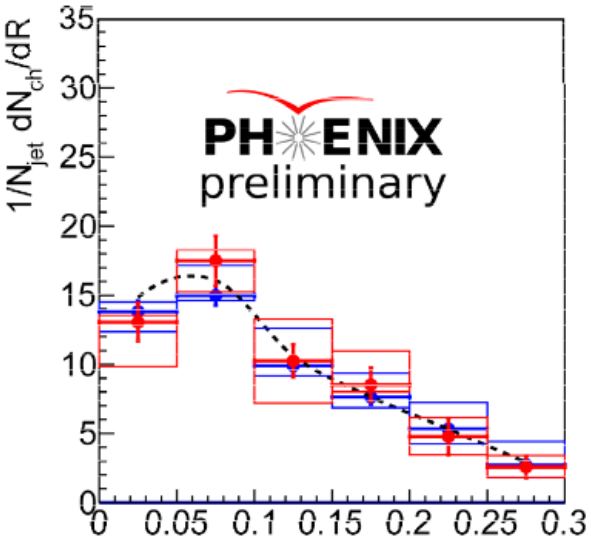
Jet splitting function



Fragmentation function $\xi = -\ln(z)$



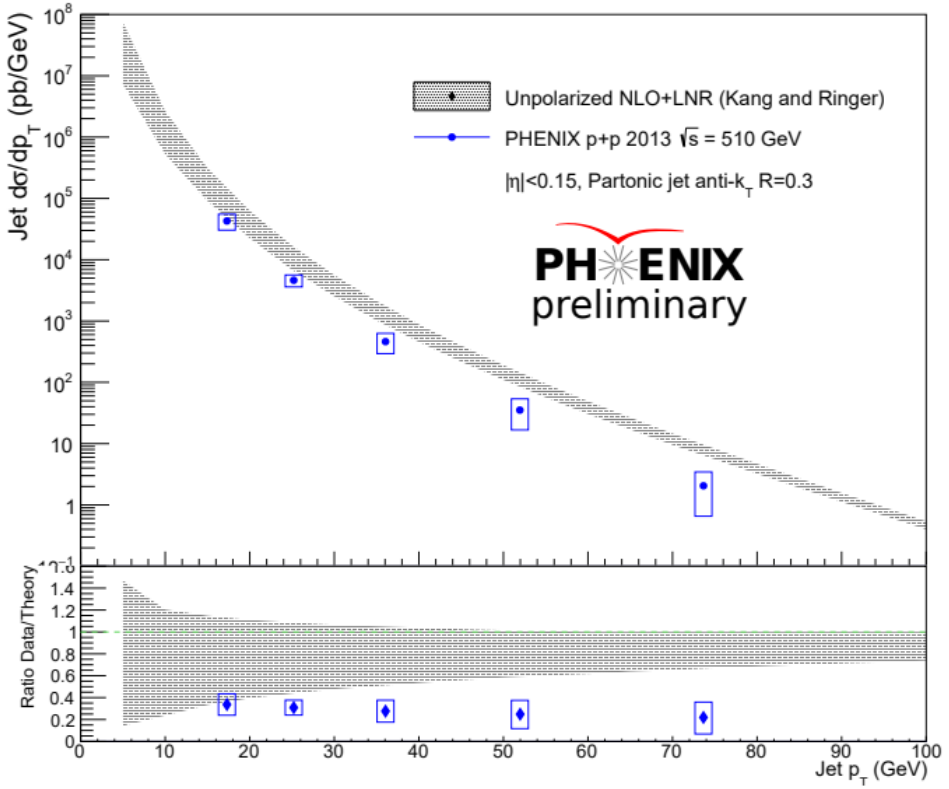
Transverse fragmentation j_T (GeV)

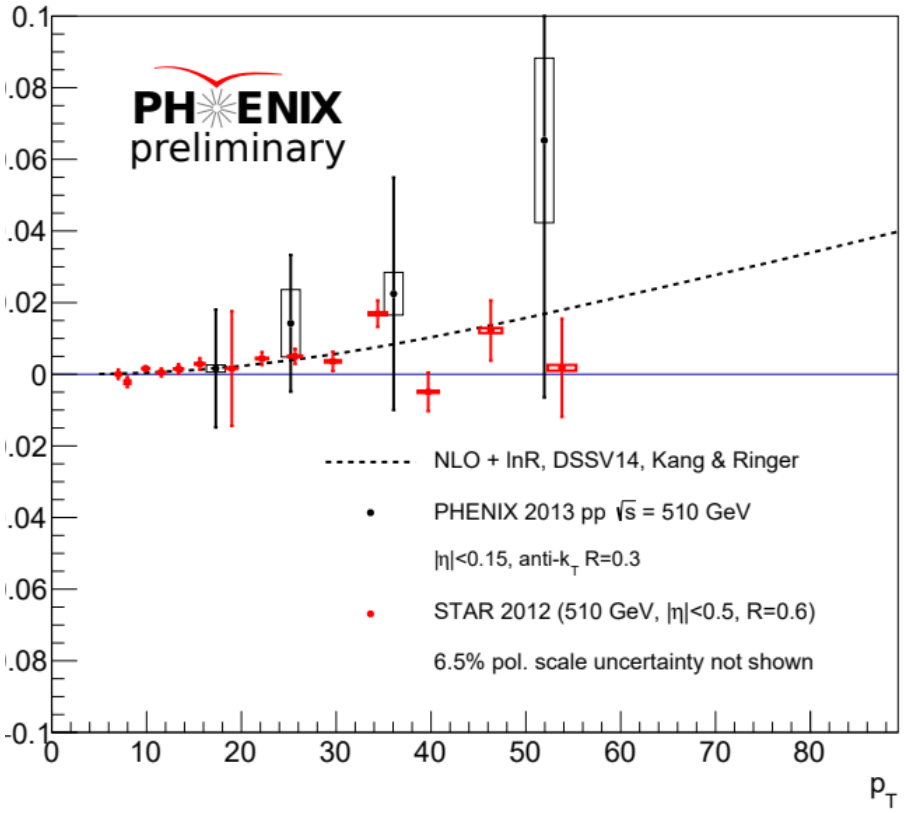


Radial profile ΔR

Jet A_{LL}

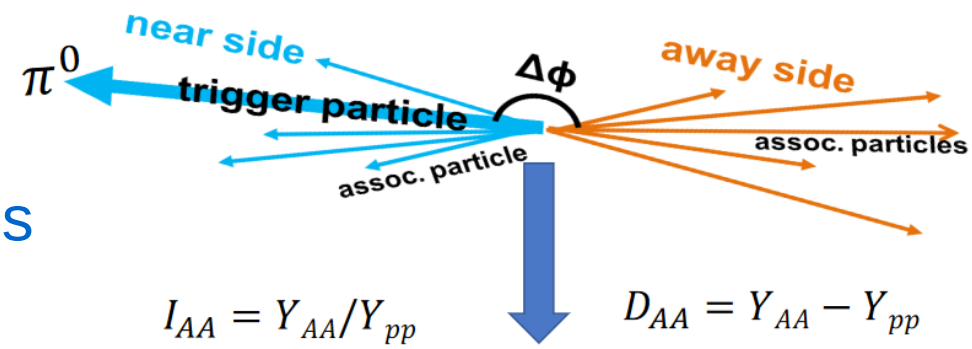
- First jet longitudinal double spin asymmetry (A_{LL}) at PHENIX
  - Helps constrain gluon helicity distribution function Δg(x)
  - Unfolded to correct for underlying event and detector effects
- Cross section below NLO prediction
  - Similar to LHC finding for small R

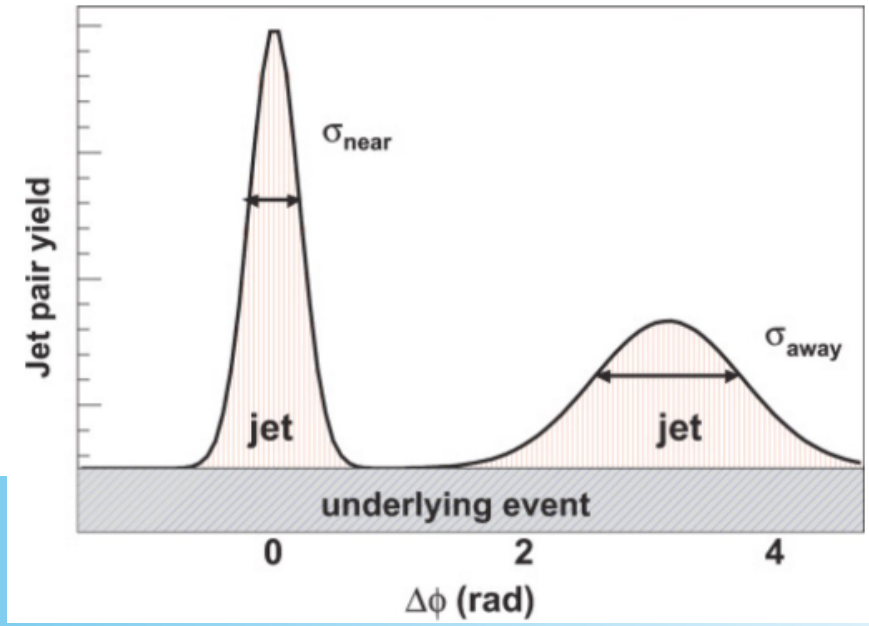




Jet Modification via π^0-h Correlation

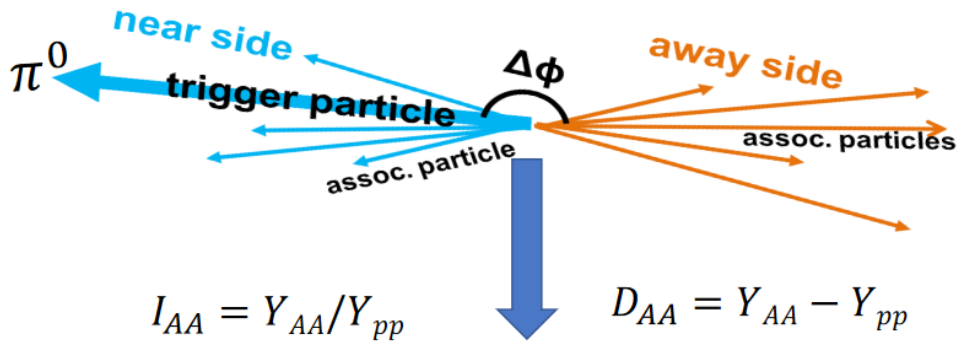
- Run 14 √s = 200 GeV Au+Au
- Jet particles affected by medium
  - Suppression indicates energy loss in QGP
- Trigger on near side jet particle
  - Away side jets are not biased by trigger requirement

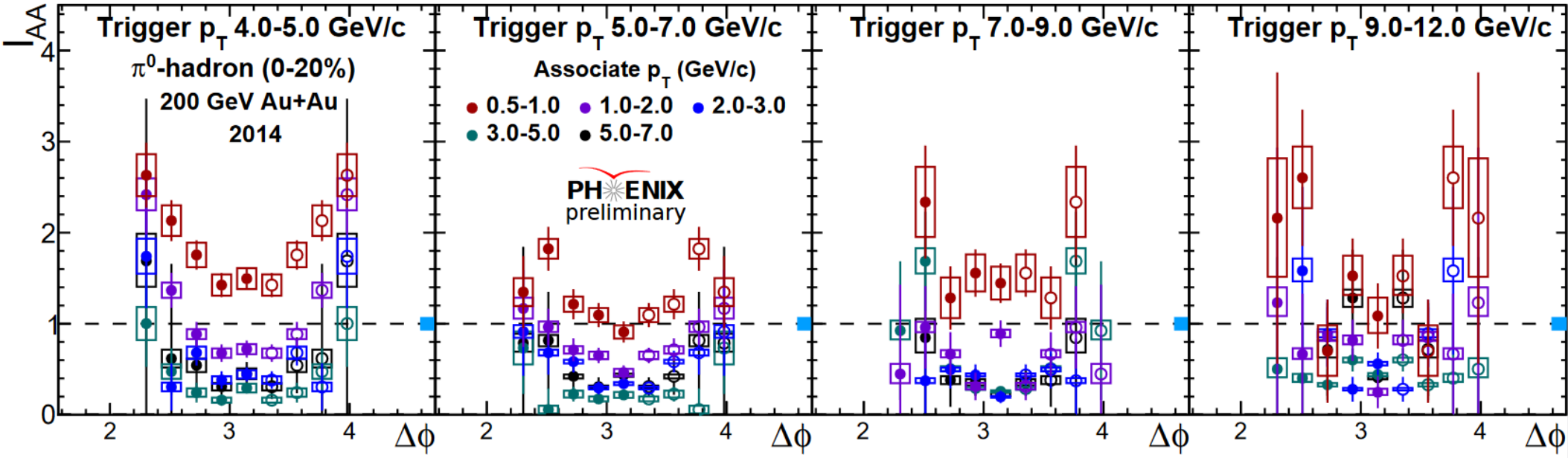




Jet Modification via π^0-h Correlation II

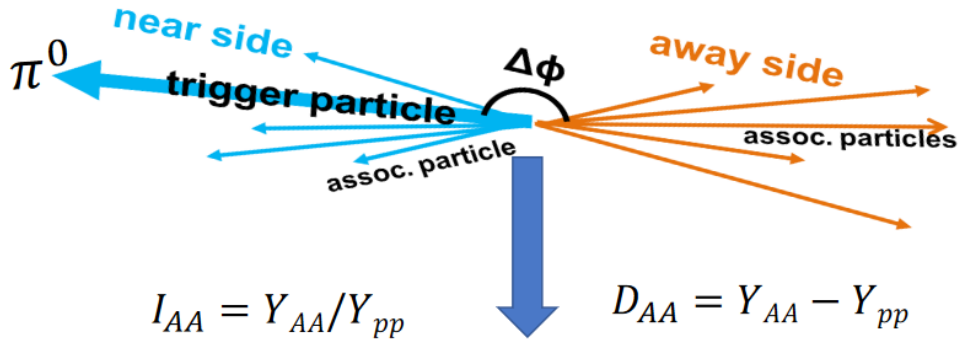
- Suppression of high p_T hadrons
- Large angles for low p_T hadrons shows enhancement

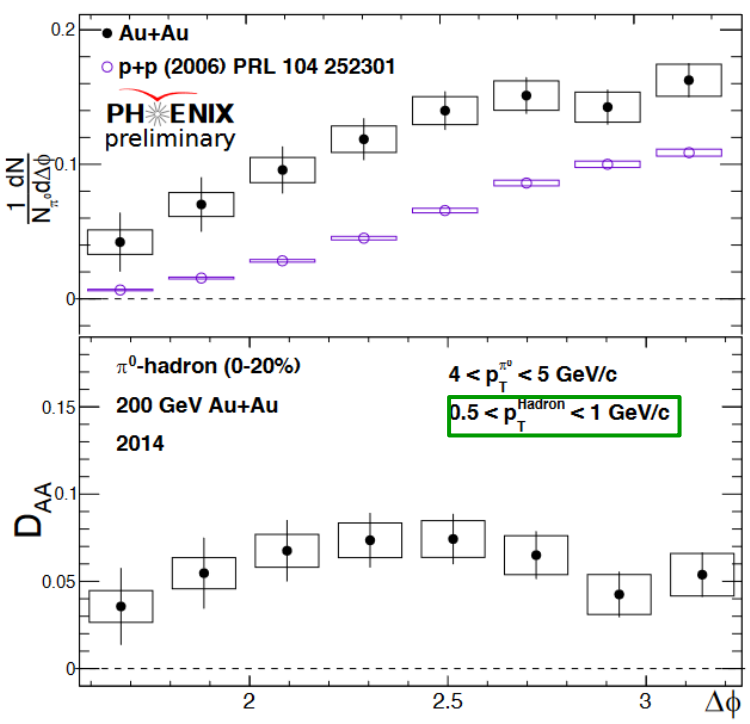


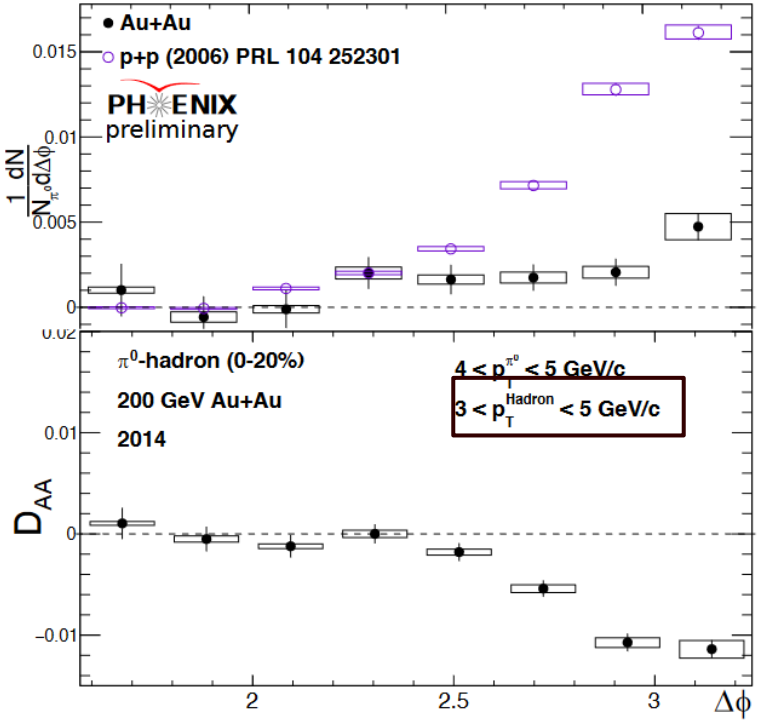


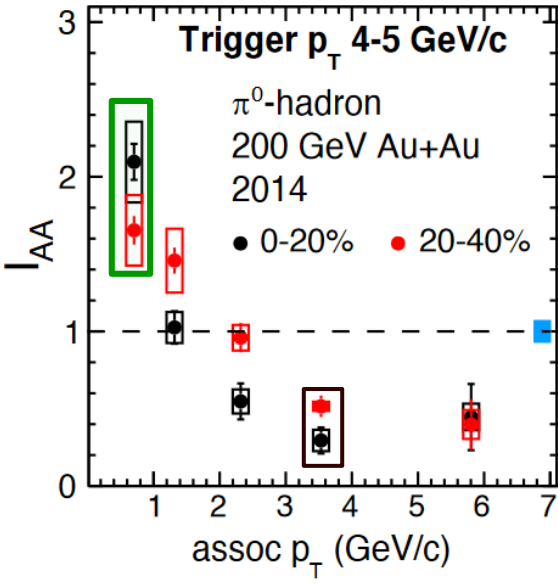
Jet Modification via π^0-h Correlation III

- Enhancement: $D_{AA} > 0$
- Suppression: $D_{AA} < 0$
- Suppression of high p_T hadrons at large angles



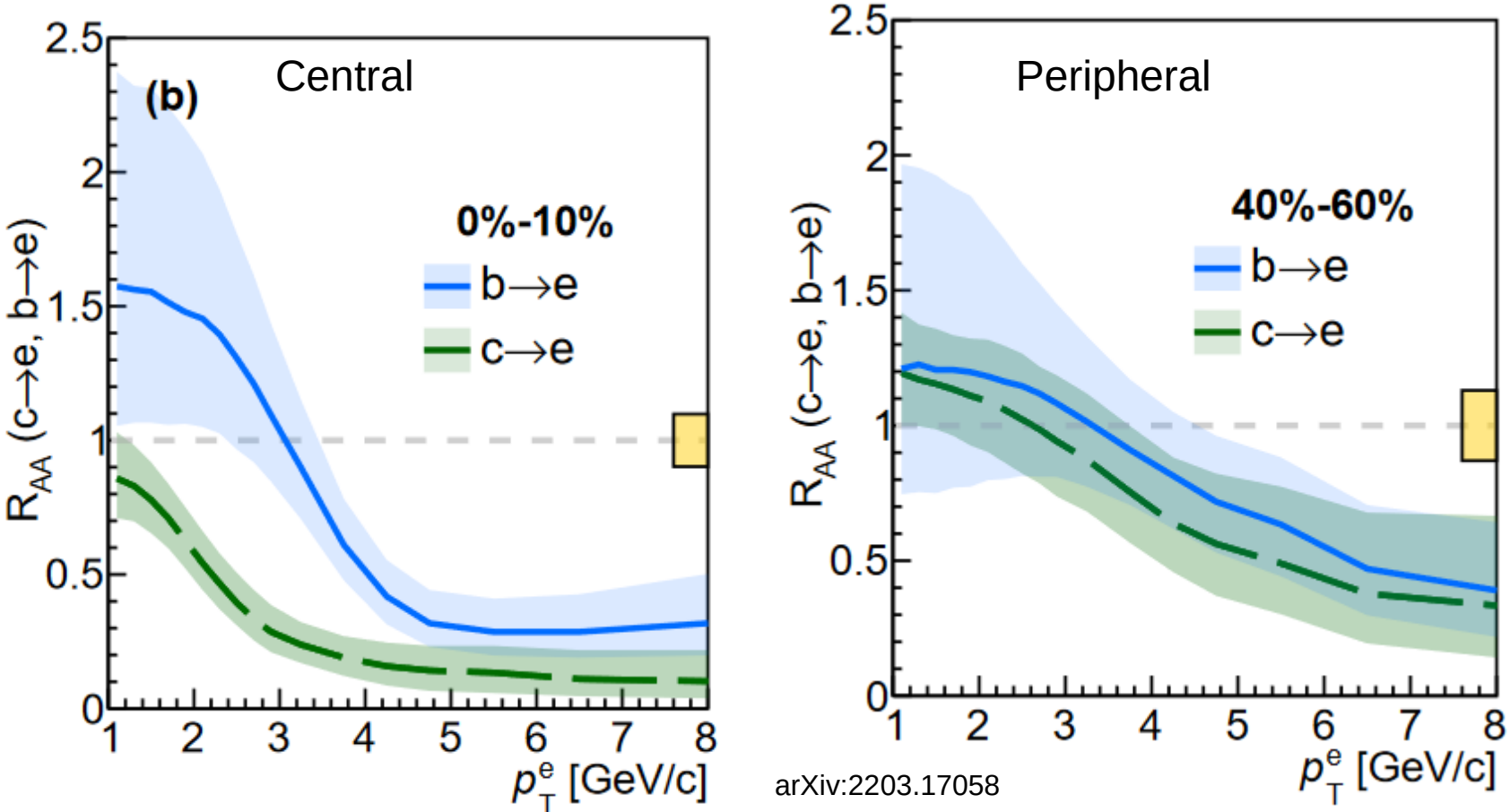






Energy Loss of Heavy Quarks in Au+Au

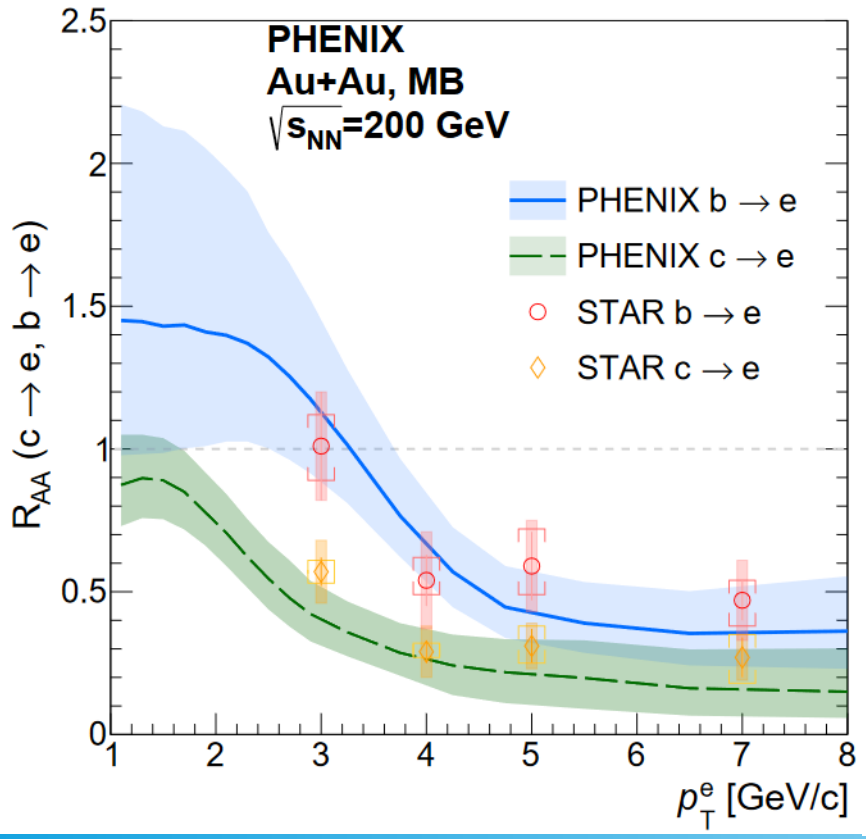
- Nuclear modification (R_{AA}) of bottom and charm electrons
  - Suffer energy loss and flow effects passing through QGP
- Central shows clear suppression
- In 40-60%, both are similar and less suppressed

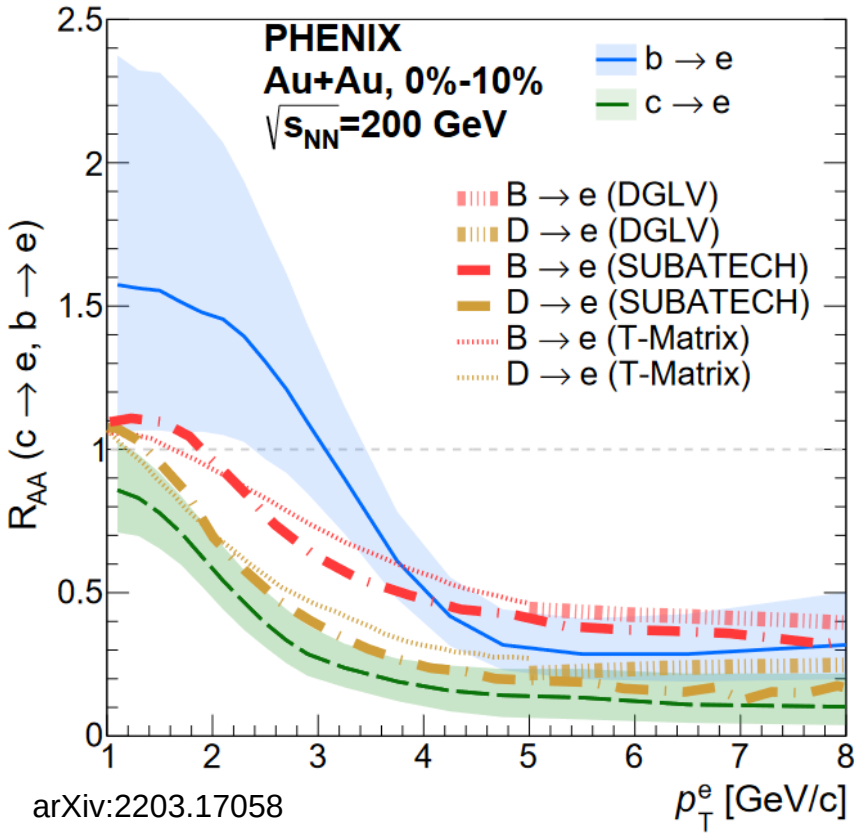


arXiv:2203.17058

Energy Loss of Heavy Quarks in Au+Au II

- PHENIX Minimum Bias (MB) and STAR are in good agreement within uncertainties
- Bottom models underestimates the data
  - Charm models slightly higher than data





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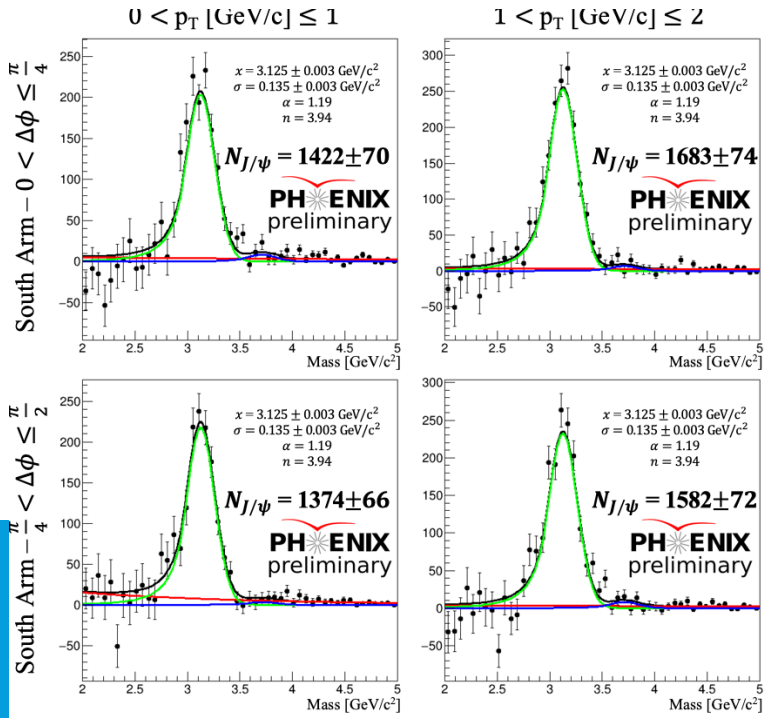
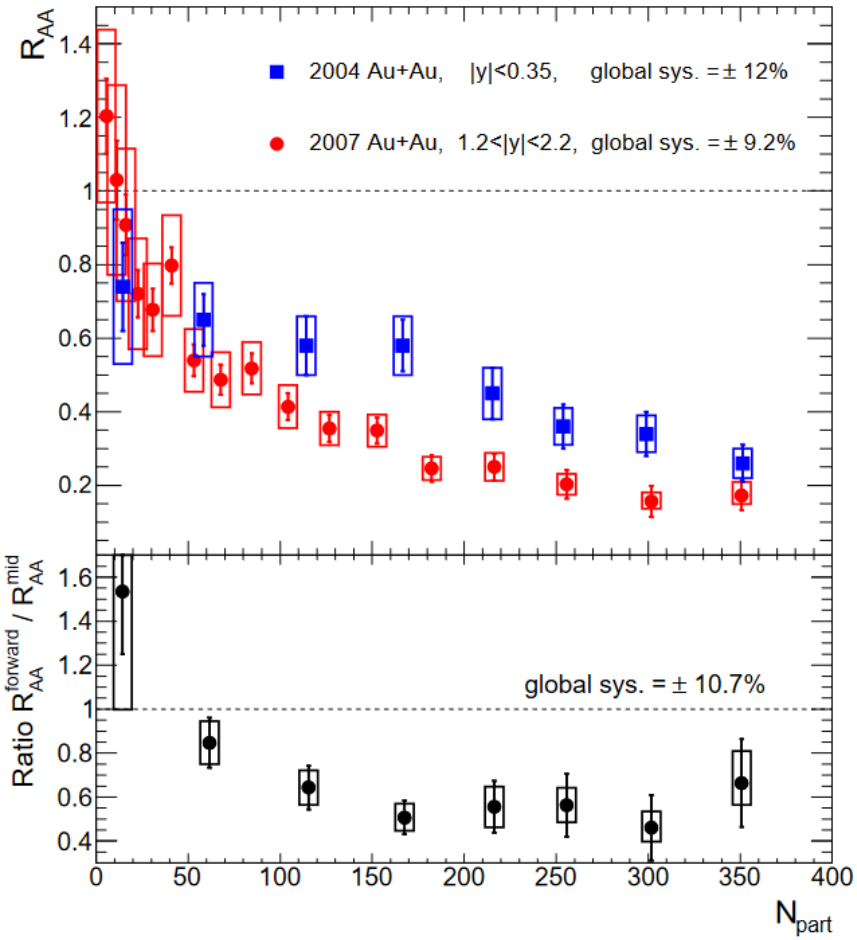
J/ψ Elliptic Flow in Au+Au

Phys. Rev. C 84, 054912 (2011)

- Previous results find R_{AA} forward is larger than mid rapidity
- Using forward Muon arms to measure J/ψ azimuthal anisotropy

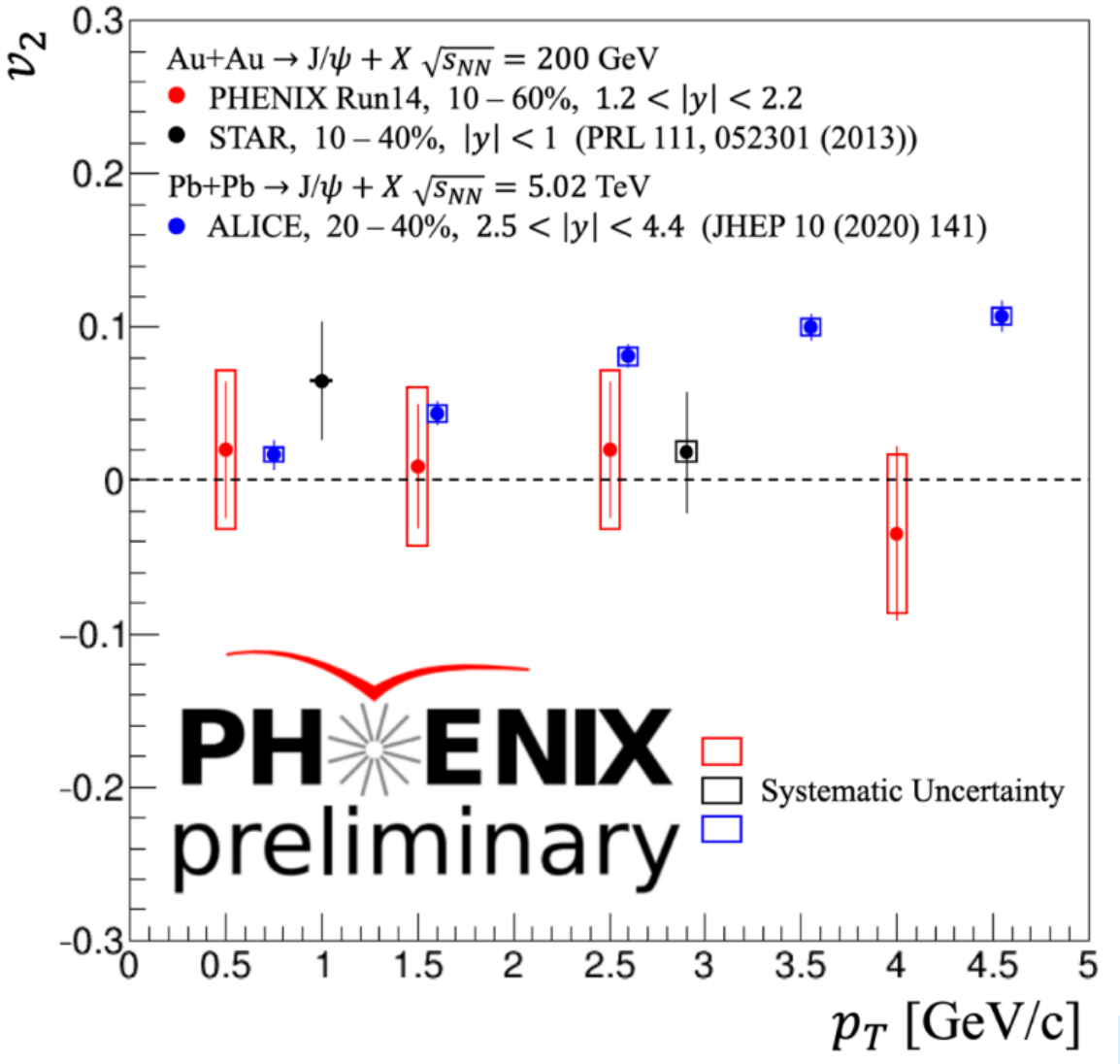


$$v_2^{obs} = \frac{\pi}{4}\frac{N_{in} - N_{out}}{N_{in} + N_{out}}$$

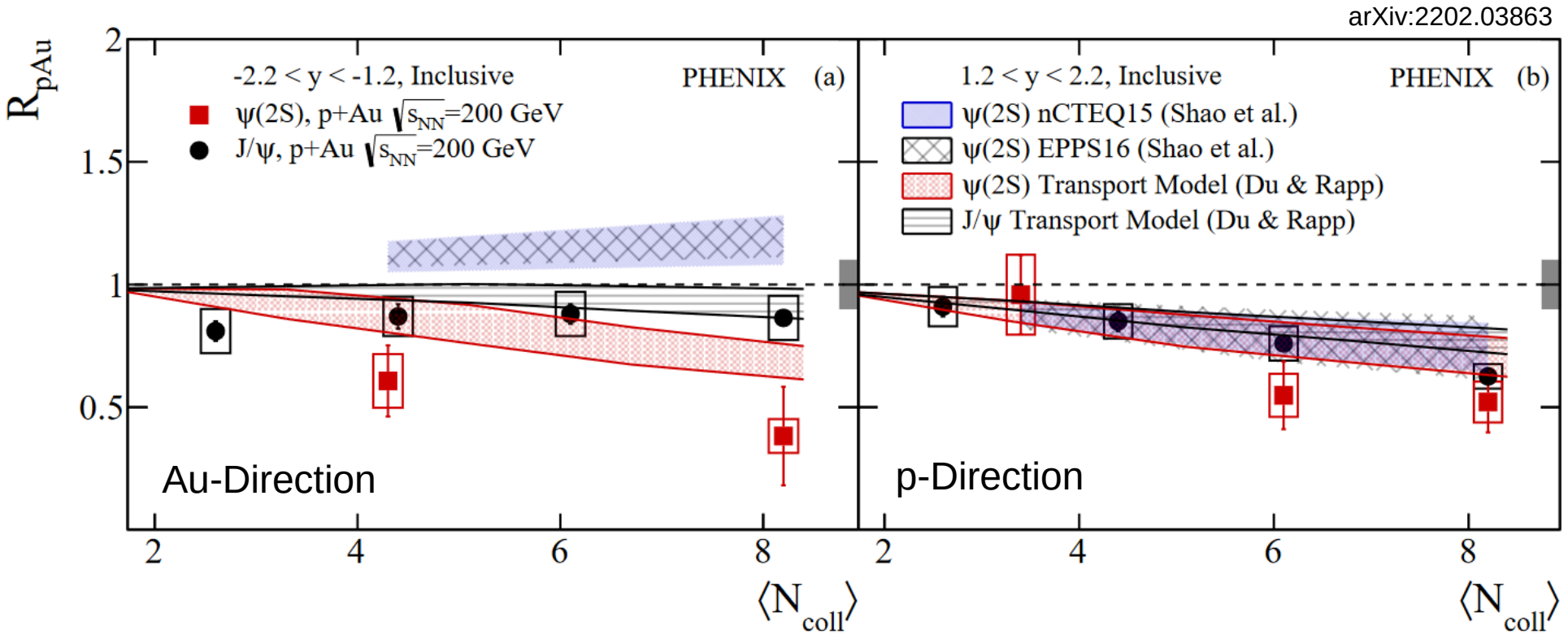


J/ψ Elliptic Flow in Au+Au II

- PHENIX J/ψ v_2 is consistent with zero at forward rapidity
- Differs from ALICE nonzero result
- Run 16 Au+Au data from will be added!

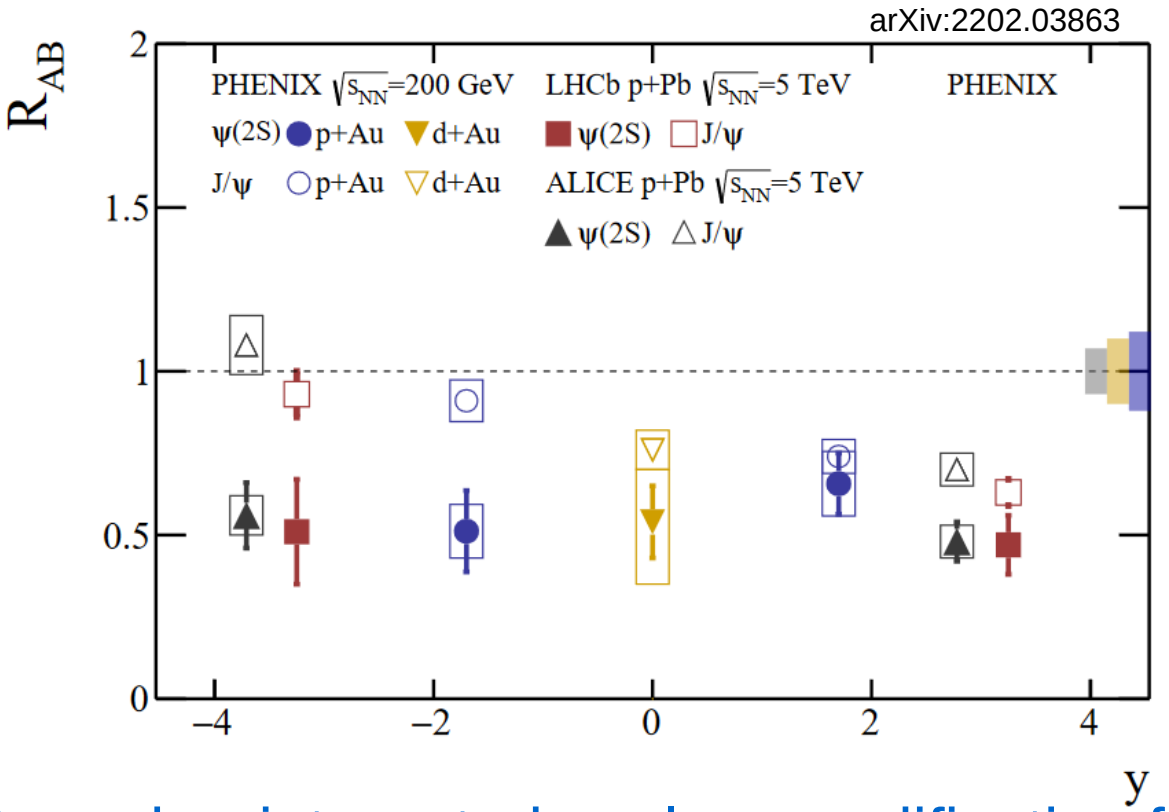


J/ψ and ψ(2S) in p+Au



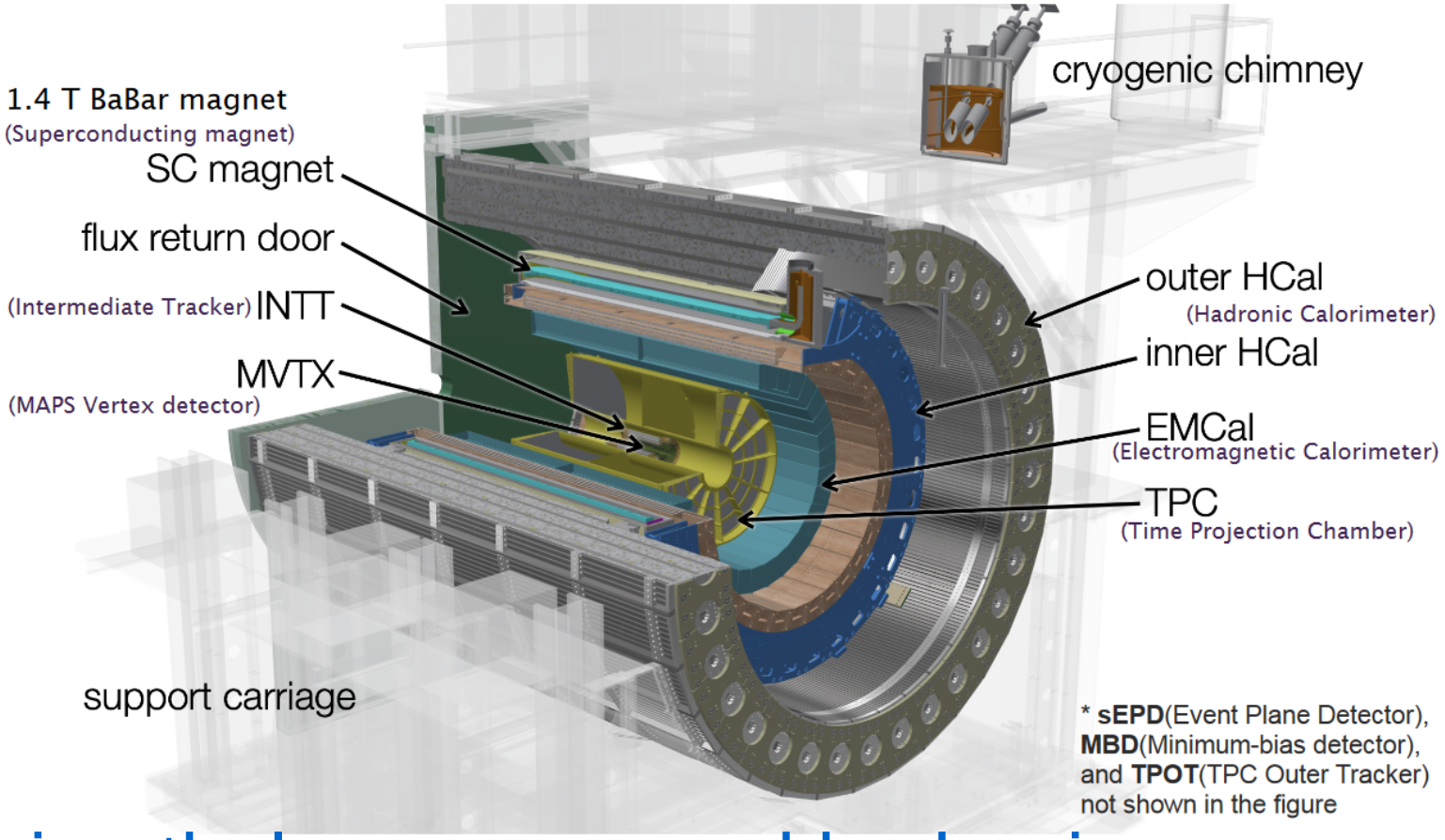
- Similar modification in the forward (p-Direction) side
- Stronger ψ(2S) modification in the backward (Au-Direction) side
- Transport Model does not fully predict the modification
  - Suggests final state effects

J/ψ and ψ(2S) in p+Au II



- Centrality and p_T integrated nuclear modification factor
- No significant difference between PHENIX, LHCb, and ALICE

sPHENIX Detector



- Full azimuthal coverage and hadronic calorimeters
  - Full jet reconstruction

Year	Species	$\sqrt{s_{NN}}$ [GeV]	Cryo Weeks	Physics Weeks	Rec. Lum. $\lvert z\rvert$ <10 cm	Samp. Lum. $\lvert z\rvert$ <10 cm
2023	Au+Au	200	24 (28)	9 (13)	3.7 (5.7) nb^{-1}	4.5 (6.9) nb^{-1}

Summary

- PHENIX data analyses still producing interesting results
  - Jet substructure, A_{LL}, two-particle correlations
  - Heavy flavor in Au+Au and p+Au to study QGP
    - Nuclear modification and flow
- New and interesting results will continue with sPHENIX!